



Understanding U.S. Strategic Interests in Expanding Renewable Energy Systems Worldwide

Summary of the
Third NREL Energy Analysis Forum
June 11-12, 2003

Organized by the National Renewable Energy Laboratory (NREL),
in conjunction with the Department of Energy (DOE) and
the U.S. Agency for International Development (USAID)

"Clean water, modern energy, good health, and productive agriculture...can lead us to a world without poverty.... We will stand together in Johannesburg to bring our full support to this important battle."

*President George W. Bush,
August 19, 2002*

"Promotion of clean energy technology exports will mitigate international dependence on oil supplies from volatile regions; help lower energy costs for the United States consumers; reduce nuclear proliferation risks; bring the United States firms greater access to large foreign markets; and enhance the United States integration with global sources of innovation."

*Spencer Abraham
Secretary of Energy
April 25, 2001*

I challenge each of you at this forum to imagine the world of information (not just data), where decisions are more consistent, more flexible in meeting changing conditions in the economy, in the environment, and in the markets – all based on emergent, high-quality analysis. The world that I see developing simply can't do without it.

*Admiral Richard Truly
Director, NREL
June 11, 2003*

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Abbreviations and Acronyms

ADB	Asian Development Bank (Manila)	www.adb.org
APEC	Asia-Pacific Economic Cooperation (Singapore)	www.apec.org
EERE	Energy Efficiency and Renewable Energy program of USDOE	www.eere.energy.gov
GEF	Global Environment Facility (Washington, DC)	www.gefweb.org
<i>GIS</i>	<i>Geographic Information System</i>	
<i>GPS</i>	<i>Global Positioning System</i>	
GVEP	Global Village Energy Partnership (London)	www.gvep.org
IEA	International Energy Agency (Paris)	www.iea.org
IIASA	International Institute for Applied Systems Analysis (Vienna)	www.iiasa.org
IPHE	International Partnership for the Hydrogen Economy	http://www.usea.org/iphe2.htm
MDG	Millennium Development Goals	www.developmentgoals.org
<i>NGO</i>	<i>Non-governmental organization</i>	
<i>ODA</i>	<i>Official Development Assistance</i>	
PREGA	Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement (Asian Development Bank)	www.adb.org
REEEP	Renewable Energy and Energy Efficiency Partnership	www.reeep.org
<i>RESCO</i>	<i>Rural (or Renewable) Energy Services Company</i>	
SNL	Sandia National Laboratories	www.sandia.gov
USDOE	US Department of Energy	www.energy.gov
<i>VP</i>	<i>Village Power</i>	
WB	World Bank (Washington, DC)	www.worldbank.org
WSSD	World Summit on Sustainable Development (Johannesburg, 2002)	http://www.un.org/events/wssd

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Many people worked to make this forum a stimulating and highly useful event. The NREL planning team included Marg Kelly, Roger Taylor, Walter Short, Michelle Kubik, Ron Benioff, Collin Green, Peter Lilienthal, Debra Lew, and David Glickson. The session chairs were Judy Siegel, Skip Laitner, Walter Short, and Debra Lew. We also thank the many speakers and also those organizations that cosponsored the forum with NREL – the U.S. Department of Energy (DOE) and the U.S. Agency for International Development (USAID).

Eldon Boes
Director,
NREL Energy Analysis Office

Background

The National Renewable Energy Laboratory's (NREL) Energy Analysis Forum focuses on analytic issues and their importance to the nation's energy efficiency and renewable energy programs. This forum was the third in a series of energy analysis forums sponsored by NREL (more information on the first and second forums can be found on the NREL Web site at www.nrel.gov/analysis). These forums are designed to bring together energy analysts with other stakeholders to address analysis related to specific energy technology, policy, or market issues. The third Energy Analysis Forum was hosted by NREL in collaboration with the U.S. Department of Energy (DOE) and the U.S. Agency for International Development (USAID).

The theme of the third NREL Energy Analysis Forum was “Understanding the U.S. Strategic Interests in Expanding Renewable Energy Systems Worldwide.” The two-day event examined the national implications of greatly expanded use of renewables worldwide, as well as the status of our understanding of the associated costs and benefits of scaling up renewables, and identified needs for additional analysis. There were more than 100 participants from the public and private sectors, academia, and other government organizations.

The objective of the forum was to present and discuss a set of issues and questions focused on the four primary topics of the forum (markets, energy security, development, and the environment). The forum was neither technology-driven nor applications oriented; rather, a broad and evolving menu of renewable energy technology options was considered within the context of the primary topics. The central concern of the forum was articulated by NREL’s Director Admiral Richard Truly at the opening of the forum.

The strategic interests of the United States in terms of global security, economic growth, and stable geopolitical relationships have the potential to be enhanced by the development and inclusion of alternative energy – including renewables – in energy systems. Exporting that technology and our experience in developing and using it will be a tremendous step forward in international relations and in furthering those strategic interests. The use of effective analysis is critical to achieving success in this area.

Admiral Richard Truly, Energy Analysis Forum, June 11, 2003

The forum sessions, which combined presentations and group discussions, examined the following specific interrelated themes:

1. Global markets — export possibilities and commercial ventures
2. Environmental — climate change and air and water quality
3. Energy security — reduced demand for fossil fuels and increased political stability
4. International development — economic growth and energy sufficiency and access.

On the second day, working groups discussed program and policy opportunities to enhance benefits and to define needs for further analysis. The final session included discussion of an analytical framework and recommendations for next steps.

The presentations that were given at the forum, as well as background on the speakers and panelists, are available on the NREL Web site at http://www.nrel.gov/analysis/forum/ea_forum_2003.html

Because of the breadth of issues and the limited time (two days) available for the presentations, discussions, and working group deliberations, in-depth discussions were not possible (nor were they intended).

NREL is continuing to explore and analyze the principal issues raised in the forum. There is a need and opportunity to pursue selected topics in greater depth, and to mobilize some of the remarkable expertise available beyond the NREL / USDOE / USAID nexus.

This short issues paper summarizes many of the key points, issues, and challenges arising from the forum. It addresses the four primary topics of the forum and identifies and discusses other relevant issues and topics. The paper focuses on what is known and not known about each of the key topic areas, identifies the analysis and analytic tools that are needed to better delineate the questions and find answers, and identifies institutions and individuals working on various aspects of the analytic questions posed at the forum.

Our focus is on analysis and assessment of the impacts of large-scale diffusion of a growing menu of renewable energy systems worldwide. Key to effective analysis will be asking the right questions, and determining the most important questions amenable to analysis by NREL and others.

Summaries¹ of the forum presentations

Session I: Introduction

Welcome

Admiral Richard Truly
Director, NREL

Admiral Truly noted that “in the ongoing energy analysis forums, we can productively engage in debate and information exchange with a diverse audience that includes Congressional staff plus those from federal agencies, important financial institutions and foundations, commercial companies, and private citizens to explore the tremendous potential *of renewable energy systems in international trade*.

“As we move toward a global economy with shared economic rewards and access to information, the responsibility to understand, monitor, and adjust to energy-driven environmental issues becomes paramount. Here, the emerging tools of energy and economic analysis can and will play a crucial role in shaping our future. This is especially true as strategies such as the International Hydrogen Initiative are devised and developed to take us into a different future.

“As demand for modern energy continues to grow, the need to enhance system design and reliability, as well as extend our sources of supply becomes more and more crucial to continuing economic health. This endeavor involves policy-makers, scientists, forecasters and regulators in a complex interaction, *all dependent on a consistent analytic foundation*. The participants at the forum represent that analytic foundation as it evolves and becomes more and more sophisticated in approach and application.

“Beyond our borders, the economies of developing nations will require growing energy supplies in the future as they strive for improving standards of living, often in the face of daunting population growth scenarios. Their energy systems must embrace a new paradigm of environmental sensitivity if they – and we – are to avoid catastrophe.

“Renewable energy can play a significant role in enhancing the production potential of emerging nations, providing the path and the stimulus to greater rates of growth of their GDP. The result will be countries that are more stable, self-reliant, and secure in their relationships on a worldwide basis, with a resulting and significant positive effect on our national security here at home.

“The strategic interests of the United States in terms of global security, economic growth, and stable geopolitical relationships have the potential to be enhanced by the development and inclusion of alternative energy, including renewables, in energy systems. Exporting that technology and our experience in developing and using it will be a tremendous step forward in international relations and in furthering those strategic interests. *The use of effective analysis is critical to achieving success in this area*.

“Renewable energy policies will influence the way new markets evolve. Given the lifetimes of energy systems along with industrial momentum, they will also continue to influence the shape and role of those same markets far into the future. *Decision-makers need effective, timely, accurate data and analysis to chart our course* and to enable mid-course corrections in order to achieve continuing success in expanding the role of renewable energy technologies world-wide. Simpler and clearer technology reports and

¹ These summaries are drawn directly from the presentations made in the forum and the discussions of each of those presentations.

crosscutting analyses are essential for the decision-making process. At stake are tremendous economic interests as well as geopolitical relationships and the social vitality of every nation we trade with.

“In today's global economy, analytic services are more valuable than ever. Between the changing needs and direction of congressional initiatives and budget streamlining to the volatility of the global economy, *our most valuable tool is dispassionate, clear, and defensible analysis.*”

“Without a clear and unimpeachable analysis function at our disposal, the credibility of the work of our entire scientific and research institution is diminished. Good analysis provides the benchmark and the framework for policymakers, researchers and budget managers as they view and compare work products. It is indispensable, and even though often misunderstood or even ignored, always in demand.”

Forum purpose and key questions

Eldon Boes, NREL

Asking the right questions is the essential first step in productive analysis. The Energy Analysis Forum began with NREL Energy Analysis Office Director Eldon Boes giving a review of the key questions to be addressed by the participants. One of the most important contributions of this forum was the development of a detailed set of questions and issues. The questions were grouped according to major forum discussion themes and a set of sub-themes. The major themes of the workshop were:

1. Global markets — export possibilities and commercial ventures
2. Environmental — climate change and air and water quality
3. Energy security — reduced demand for fossil fuels and increased political stability
4. International development — economic growth and energy sufficiency and access.

The workshop focus was on better understanding our strategic interest in the global use of renewable energy from the perspective of the U.S. Department of Energy.

- What are DOE's interests in global energy systems, and how are these pursued?
- From DOE's perspective, what are the benefits and challenges regarding the use of renewables in global energy systems?
- What additional information or analyses are needed to better understand the role of renewables in supporting DOE's goals and programs for global energy systems?

Specific topics that were explored under each of these major themes included the following:

Global Markets

Market Implications

- How well are global energy markets understood?
- How well is the potential role of renewables in these markets understood?
- What are the potential roles of the U.S. (government and industry) in these markets?

Global markets for renewables

- What are the global energy system markets today and for the next several decades?
- What is the potential role of renewable energy systems in these markets?
- What is the market share of U.S. manufactured product in these markets?
 - How is U.S. content and company ownership changing?
- What are the economic opportunities for the U.S. in serving these markets?
 - How does multi-national company involvement benefit/hinder the U.S?
- What additional data or analyses are needed to improve the quality of our information on these questions?

European Perspectives on Global Energy Markets and Renewables

- What are prevailing European views regarding global energy markets and the role of renewables in those markets?
- How do Europeans tend to view their strategic interests in these markets?
- What actions are Europeans taking to serve these markets?
- What questions regarding these issues deserve further analysis?

U.S. Energy Industry Perspectives

- What and where are global power markets today and for the next few decades?
- What are the key drivers for these markets, both their size and their technology preferences?

- What is the potential role of renewables in these markets?
- What opportunity do these markets offer U.S. industry?
- What additional information would be valuable to better understand the role of renewables in these markets?

Environmental /Health Issues

Environmental Implications

- What are the implications of global warming for future energy systems?
- What are the implications of global warming for the potential role of renewables in global energy systems?
- What are the associated implications for the U.S.?
- How well do we understand the climate change-related costs and benefits to the U.S. of expanding global use of renewables?
- What additional information or analysis is needed?

Public Health (including air quality issues)

- What are the impacts of current and projected energy systems on public health around the world?
- What implications do these impacts have for the potential role of renewables in global energy systems?
- What are the implications for the U.S. of these global energy-related health issues?
- How well are these energy-related health issues understood?
- What additional information or analyses are needed?

Energy Security

Energy Security Implications

- What are the key links between security (energy and other) in the U.S. and global energy systems development?
- How much do U.S. security impacts depend on what energy resources and technologies are used in global energy systems development?
- What are the security pros and cons related to the role of renewables in global energy systems development?
- What key questions regarding this issue deserve further study?
- What are the connections between terrorism, political stability, and economic development?
- What is the role of energy systems in supporting political stability?
 - In social/infrastructure development?
 - In economic development?
- What are the technology, policy, and market issues to be addressed?
- How well do we understand these issues?
 - What additional data, information, or analyses are needed?
 - What can go wrong?

Intersecting Issues of Energy and Water

- What are the current and projected water needs around the world?
- What are the related strategic interests to the U.S.?
- What are the implications for energy-systems development?
- What are the relative costs and benefits of different energy resources or technologies for meeting water needs?
- What additional data or analysis is needed?

International Development

International Development Implications

- What is the role of local energy-systems development in local economic development?
- What are the pros and cons of different energy resources or technologies in local economic development?
- What are the key energy/economic development issues deserving of additional study?

Development Institution Perspectives

- What is the role of energy in economic development programs?
- What is the potential role of renewables in global energy markets, and in development programs? What are the key drivers for competing energy technologies?
- What are the challenges and opportunities to U.S. industry in supplying energy systems for global economic development?
- What additional information would be valuable to better understand these questions?

Understanding our strategic interest in the global use of renewable energy: a perspective from USAID

- What role does energy play in USAID's goals and programs?
- What are the benefits and challenges regarding the use of renewables from USAID's perspective?
- What additional information or analyses are needed to better understand the role of renewables in supporting USAID's goals and programs?

Energy, Food, and Agriculture

- How important are agriculture and food production to economic development around the world?
- What are the energy implications of agriculture and food production around the world?
- What are the pros and cons associated with the use of renewables to meet energy needs for agriculture and food production?
- What are the implications for OECD countries of greater use of renewables for agriculture/food production in developing countries?
- How well do we understand these issues, and what additional data or analyses are needed?

Productive Uses of Energy in International Development

- How important are productive uses of energy for economic development around the world?
- What are the implications for local and global energy-systems development?
- What is the potential role of renewables in these productive uses?
- What are the implications for the U.S. of different levels of renewables' contributions to economic development in other nations?
- How well are these questions understood, and what additional information is needed?

It is clear that energy is a pervasive component of almost everything that we do as a society. It is perhaps less clear where we should focus most of our technological, financial, and political resources. Without clear and compelling analysis, it is not possible to identify priorities and strategies. In the following pages, the issues and questions presented above are addressed, and some recommended priorities and approaches are presented for NREL analytic activities.

USAID Perspective

Griffin Thompson, USAID

Griffin Thompson presented a concise view of USAID's primary commitments and of the role of energy in supporting programs that are responsive to those commitments. The focal points for USAID's programs are: 1) promoting democratic government, 2) driving economic growth, 3) changing health needs, 4) mitigating and managing conflict, 5) providing humanitarian aid, and 6) taking the full measure of U.S. development assistance, reflecting the reality that Official Development Assistance (ODA) is just one element of the U.S. foreign aid budget.

USAID's Office of Energy works to integrate energy into all of USAID's programs. While this is often challenging due to cognitive and bureaucratic barriers, there have been some notable successes that can and will serve as models for replication. These include the following:

- Water and Energy Nexus
- Health and Energy – such as indoor air pollution reduction
- Energy and Telecommunications and Information Technologies – distance learning (policy reform)
- Energy and economic growth – financing and entrepreneurial development
- Energy and Democratization
- The Clean Energy Initiative and the Global Village Energy Partnership (GVEP), for which USAID has primary responsibility within the U.S. government.

Benefits and Challenges

There are benefits from and challenges to the widespread use of renewable energy technologies in the context of USAID's mandate and programs. Benefits include the following:

- Renewable energy technologies (RETs) and the attendant sociopolitical systems they require, and which ultimately follow in the wake of technological diffusion, conform to and align with the social, economic, and political conditions of the developing world.
- RETs are, in many cases, the necessary antecedent condition for full realization of USAID's goals and objectives in many areas, such as promoting empowerment of women.
- There is an elegant symmetry between two global trends: 1) the decentralization and devolution of political and administrative power to local, sub-national entities, and 2) the technological downsizing *[and expansion of the options for distributed generation]* of electric generating technologies. There is a powerful convergence of these two trends. The results may be profound for the future of social, economic, and political development. *It may be that distributed generation is a natural part of the evolution of the energy infrastructure.*

The challenges are twofold. In addition to the widely discussed barriers to increased diffusion of RET within the context of foreign assistance and international development work, there are the added issues of *institutional inertia and cognitive cul-de-sacs*.

Additional information and analysis needed to better understand the role of renewables.

Much more than technological issues, social and political institutional issues continue to defy resolution. Manuel Castells, a sociologist and leading thinker on issues of technology and of the future, reminds us that “No major historical transformation has taken place in technology, or in the economy, without an interrelated organizational transformation.”

Therefore, we need more analysis and information on what the new systems will look like and the design components of that system. We should employ current thinking of network logic and organizational structure and adapt those to the energy system. This issue is too important and too significant in its implications to leave just to the energy community to solve. We need to reach out to new communities of practitioners, thinkers, and consumers to come up with the answers.

U.S. DOE Perspective

John Millhone and Robert Dixon

Office of Energy Efficiency and Renewable Energy (EERE)

U.S. DOE

The international goal of the EERE program is to accelerate the international transfer of U.S. energy efficient and renewable energy technologies to help achieve U.S. energy, environmental, economic, social, political, and security objectives. DOE is providing leadership in the development and deployment of energy efficient and renewable energy technologies to leverage financial support from other public agencies, private sources, and financial institutions to enable DOE to maximize progress toward its international goal. Initiatives include multilateral and bilateral agreements, clean energy technology exports, the Clean Energy Initiative announced at the World Summit on Sustainable Development (WSSD) in 2002, bilateral climate change cooperation, and the International Partnership for the Hydrogen Economy (IPHE).

The range of U.S. DOE bilateral and multilateral initiatives in energy efficiency and renewable energy was presented. Millhone highlighted the U.S. DOE Clean Energy Initiative (CEI), comprised of three performance-based, market-oriented sustainable development partnerships with developing economies:

- The *Global Village Energy Partnership* (GVEP), led by USAID, with the goal of facilitating access to modern energy services for an additional 150 million people;
- *Energy Efficiency for Sustainable Development*, led by DOE, working to achieve an overall average reduction in energy intensity of 20% in 20 countries; and
- *Healthy Homes and Communities for Children*, led by EPA, with the goal of reducing annual deaths attributable to indoor air pollution by 3 million.

The U.S. DOE research and development program includes a significant long-term commitment to supporting and facilitating the emergence of the key technologies and capabilities for a hydrogen economy. This work is being conducted through the International Partnership for the Hydrogen Economy (IPHE). In the long run, renewable energy resources could provide the primary energy input to a hydrogen economy. This long-term possibility is part of the vision for the U.S. work on the hydrogen economy and on understanding the potential roles of renewable energy options in supporting that economy.

Setting the Context

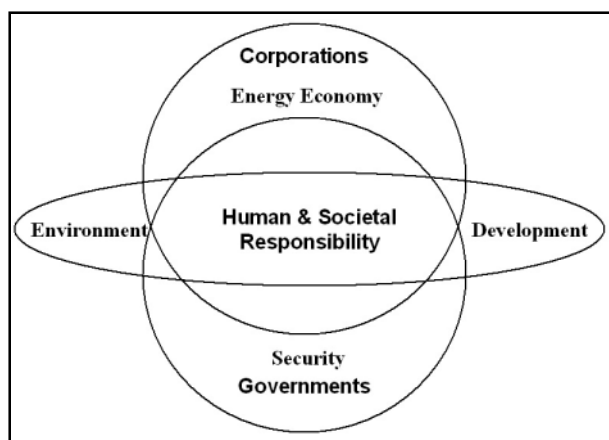
Roger Taylor, NREL

Renewable Energy in a Global Context: A Framework for Thought (a work in progress)

To set the stage for the workshop discussions, Roger Taylor took a global and long-term look at energy issues and their interaction with population growth, the evolution in human settlement form, environment, corporations and their role in the energy economy, and governments in their role in the energy economy.

As global populations grow, and if those populations are to maintain or move to improve their economies the increased demand for electricity and transportation fuels will increase. **Figure 1** shows one view of overlapping responsibilities for management of energy growth on the planet. Corporations (the private sector) and governments (the public sector) share responsibility for energy development, delivery, and use. This responsibility must also be respectful of the environment, and enable a basic quality of life in the developing world that, at a minimum, satisfies basic human needs. All people on the planet breathe the same air, and it is in our collective self-interest to wisely balance the issues of energy supply, demand, profit, the environment, and the needs of the 40% of the world's population with inadequate access to clean, affordable energy supplies.

Given this complex set of interactions, he asked the following questions about the “big picture” of energy and humanity:



- What are the areas where we know that there are analytic linkages and work underway? (e.g., climate and energy).
- What are the areas and linkages where we don't understand the dynamics and little or no analytic work is underway? (e.g., security and rural economic development, energy and water)
- How can we best approach these issues, combining the best of analysis, synthesis, and judgment?
- What form(s) of analysis are appropriate to tackle this integrated, interdisciplinary, nonlinear, mixed quantitative / qualitative problem?

Figure 1. Intersecting considerations for energy

Based on the conceptual approach to the interacting concerns of the energy economy, environment, development, and security, he concluded that we need a comprehensive, socio-techno-economic “model” for global energy expansion planning. This approach connects the commercial, social, and security issues in a way that helps us understand and communicate the challenges facing the current energy-economic framework – and the increasingly important role of renewable energy. A rebalancing of the global energy mix as environmental degradation, supply constraints, security concerns, and population grows is inevitable. A much better analytic underpinning for this dynamic process of technology shifting is urgently needed if we are to understand the forces at play. Only by a better understanding will we, perhaps, avoid impending supply constraints, and the unpleasant surprises that will inevitably occur under a business-as-usual scenario.

Some of the broad features of such a model or cluster of models would include:

- Year-by-year simulation over long periods (e.g., 50-100 years)
- Country-based supply and demand forecasts
- Based on life-cycle costing principles
- Least cost (to society, to individual countries)
- Tracking fossil fuel price and reserves
- Simulating RE manufacturing and deployment scale-up
- and much more, such as environmental feedback loops, and security concern (supply problem) identification.

Lacking such a model that tries to capture major energy flows (electricity and transportation fuels), the growth in demand, emerging supply constraints from fossil fuel depletion to renewable energy technology manufacturing, and measures of success on the environment and global human development – the U.S. will always remain in the crisis-reaction mode of energy problem solutions. This is not a formula for sustainable human development, in the United States or elsewhere.

Session II: Global costs and benefits of increased use of renewables

Session II-A: Market implications

Session introduction

Judy Siegel, Energy and Security Group, chair

Global Power Markets: Why Should the U.S. Care?

Lisa Frantzis, Navigant

Renewable Energy: A European Perspective

Rick Sellars, International Energy Agency

Energy Perspectives: A Promising Future

Pete Duprey, GE Power Systems

Renewable Energy Markets in Developing Countries

Eric Martinot, Global Environment Facility

Session presenters were asked to focus on the following questions:

1. How well are global energy markets understood?
2. How well is the potential role of renewables in these markets understood?
3. What are the potential roles of the U.S. government and industry in these markets?
4. What are the potential roles of the U.S. government and industry in these markets?

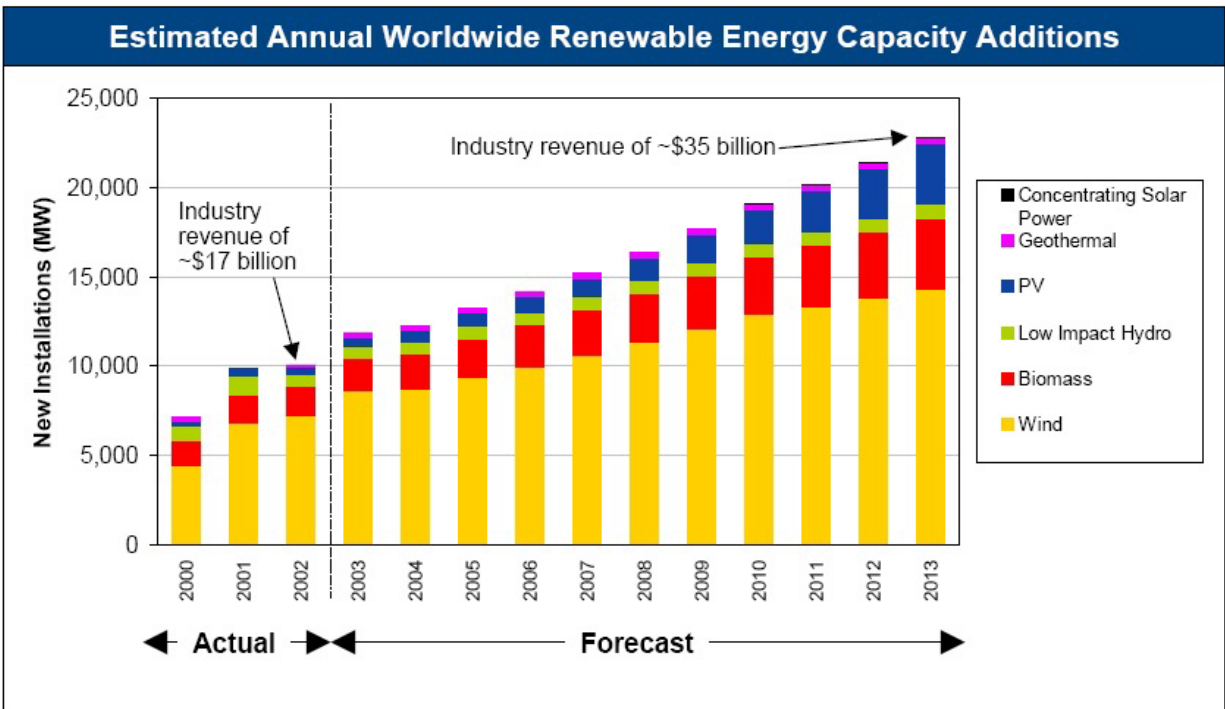
Key responses and information are summarized below. In Figure 4 below, from Lisa Frantzis' presentation, shows the expected growth in global renewable energy installations over the coming decade.

How well are global energy markets understood?

- Electric power needs outside of North America represent ~75% of the total world market power demand today and this will be true a decade from now (in 2013).
- Although there will be significant commercial opportunities for use of photovoltaics in the United States during the next 10 years, 86% of the demand is outside of the US.
- Key drivers of policies influencing energy markets include environment, local / regional development needs and patterns, local job creation, security of supply, off-grid solutions, global demand, and fossil-fuel prices.
- Social benefits and quality of life issues – rather than income and economic benefits – have driven off-grid markets for renewable energy in rural areas.

How well is the potential role of renewables in these markets understood?

- Global worldwide cumulative power capacity is projected to grow from ~3,700 GW in 2003 to 4,800 GW in 2013.
- Renewable energy capacity in 2013 is expected to reach ca. 300 GW, compared to about 116 GW in 2002, with wind and biomass energy technologies providing the largest market shares.
- Opportunities for wind energy development in Europe and Asia Pacific are expected to increase in the next 10 years.
- There is significant potential in energy efficiency (eco-buildings) and alternative motor fuels.
- Many view wind as the most economical renewable today.
- There has been a significant growth from 1971-2000 – policies make a difference.



According to Eric Martinot (**Table 1**, updated since his forum presentation), the total annual investment in renewable energy was about \$24 billion worldwide in 2003, up from \$6 billion in 1995 (all figures are in year 2003 dollars). The cumulative investment in renewable energy between 1995 and 2003 was \$124 billion. Technology investment shares for the \$24 billion total in 2003 are wind (34%), solar hot water (28%), solar photovoltaics (22%), small hydro power generation (9%), biomass power generation (4%), and geothermal power and heat (3%).

Technology	World - all countries MWe	Developing countries MWe	Developing Country Fraction
Small hydropower (≤ 10 MWe)	56,000	33,000	0.59
Wind power	40,000	3,100	0.08
Biomass power	35,000	18,000	0.51
Geothermal power	8,800	4,100	0.47
Solar thermal power	350	0	-
Solar PV power (grid-connected)	1,100	0	-
Total renewable power capacity	141,250	58,200	0.41
Large hydropower	730,000	340,000	0.47
Total electric power capacity	3,700,000	1,300,000	0.35
Source: Eric Martinot (2003-2004) www.martinot.info/market.htm and Eric Martinot			

Estimated COE Reductions

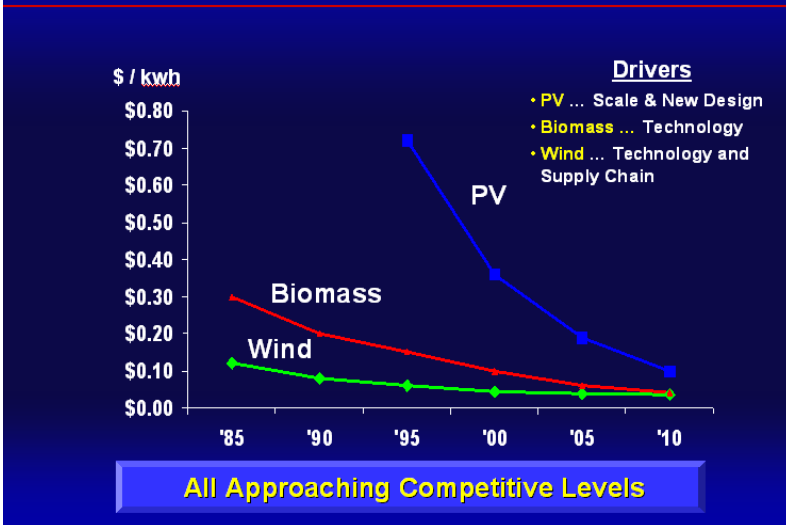


Figure 5: The reductions in the costs of energy (COE) from various renewable energy options are projected by General Electric to continue, with wind, PV, and biomass systems approaching and achieving cost competitiveness even without internalization of externalities.

What are the potential roles of the U.S. government and industry in these markets?

- For industry, the renewable energy equipment business is expected to reach about \$35 billion² annually by 2013 – it currently is about \$17 billion annually.
- Future growth in renewable energy markets will be driven by reduction in total installed system costs for technologies, including internalization of environmental costs in all energy products, and market shifts through targeted policy initiatives.
- Government programs are among the many drivers creating a sustained market demand for renewable energy.
- Policies from many countries, especially the OECD countries, are supporting and facilitating market development for renewables.
- Large corporations are staking out positions to capitalize on growth opportunities – the U.S. needs to be well positioned to compete.
- Confidence is growing in the use of renewables in grid-connected applications and markets, thanks to subsidy programs.
- The United States needs to increase awareness, educate, communicate the benefits, and be a good neighbor!
- The government needs to help shape legislation.
- Strategies need to focus on helping private firms enter new markets and innovate – financing vehicles (such as revolving funds, credit lines, etc.) need to provide support.

Overall, the panel agreed that policies can have a significant impact on market growth. Specific renewable energy incentives during the past few decades in the United States and other OECD countries (especially in Germany, Spain, Japan, and Denmark) have stimulated the emergence of major commercial PV, wind, bioenergy, and solar thermal industries

² All U.S. dollar figures are in year 2003 dollars.

Session II-B: Environmental implications

Session introduction

Skip Laitner, U.S. Environmental Protection Agency, chair

Long-Range Transport of Air Pollution

Terry Keating, U.S. Environmental Protection Agency

Climate-Change Issues

Jae Edmonds, Joint Global Change Research Institute (JGCRI)

Air Quality and Public Health

Aaron Cohen, Health Effects Institute (HEI)

Panelists were asked to focus on the following questions:

How well do we understand the environmental implications of global energy-systems development?

- We know that a variety of pollutants are transported long distances (dust storms, fires, etc.)
- While most air-quality problems are due to local or regional sources, the United States is an importer and an exporter of air pollutants.
- Development of renewable energy sources – such as biomass – is crucial to addressing the need for a reduction in the growth in emissions of greenhouse gases.
- Air pollution from combustion of fossil fuels has significant health effects – there is potential for significant health benefits from reducing reliance on fossil fuels.

How well do we understand the role of renewable energy in mitigating environmental impacts?

- Development of renewables will change the magnitude, distribution, and characteristics of emissions.
- Use of renewable energy sources will provide opportunities to decrease multiple pollutants and achieve multiple policy objectives simultaneously.
- Stabilization of greenhouse gas concentrations is crucial – global emissions must peak in the decades ahead and then decline indefinitely.

How well do we understand the costs and benefits to the United States, regarding the role of renewables in global energy-systems development?

- Renewables will provide potential cost-effective means of achieving domestic goals.
- Stabilization could dramatically change global energy and land use, resulting in increased general agricultural productivity and increased biomass penetration, nationally and globally.

What additional data or analyses are needed to better understand these environment-related issues?

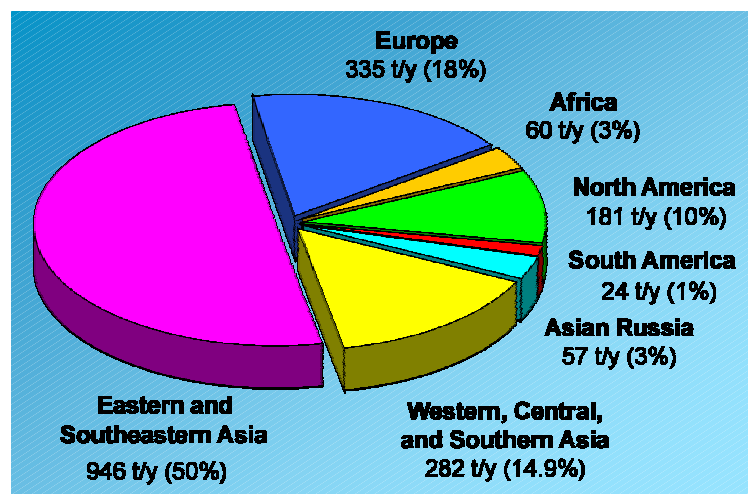
- Models provide useful insight, but “the complexity challenges the limits of our current models.”
- We need to know how much of a role renewables and energy efficiency play in creating climate change.
- Additional research is needed to reduce uncertainty in estimating attributable and avoidable burden of disease.

Overall, the panel emphasized that there is substantial evidence that fossil fuels are sources of environmental problems and related health effects. However, there is uncertainty in the views as to what renewables can do (and by when) to alleviate some of these problems. A goal of analysis in this arena is to identify the rate and scale with which renewables could displace the otherwise encountered environmental impacts of fossil fuels.

Terry Keating of the Environmental Protection Agency (EPA) discussed some of his analysis that examined the long-range transport of air pollution. Regarding “what we know,” Keating outlined how a variety of pollutants – Hg, POPs, O₃, particles, pathogens, and radioactivity – are transported long distances.

These pollutants, which can be transported through discrete events and through increases in the hemispheric or global burden, affect overall air quality. The mechanisms for transporting these pollutants depend on their characteristics. For example, dust storms and fires are types of discrete transport events. Keating talked about a huge dust cloud that formed over China and was pushed eastward by a frontal system in April of 1998 – nine days later, some of the dust actually reached the California coastline.

While most air quality problems are due to local or regional sources, the United States is both an importer and exporter of air pollutants. Researchers have discovered transboundary flows of emissions with both Canada and Mexico. Keating said that major emissions sources have been located along both borders, and new sources continue to be built.



Courtesy Terry Keating

**Global mercury emissions inventory for 1995
(contributions of different continents)**

Researchers have also discovered that 40 percent of all Hg (mercury) deposition to the lower 48 states comes from emission sources outside the United States or from U.S. emissions that have been transported across international boundaries. Imports of several pollutants to Alaska and the Arctic are carried into the area and trapped by circulation patterns.

Keating said a primary environmental implication for the United States is evident in the developing world. Continued population growth and energy use is expected in developing countries, especially in Asia. As emissions increase elsewhere, it will become increasingly difficult to meet objectives here in the

United States. According to Keating, the ozone impacts of future growth in Asia could be enough to offset the benefits of a 25% decrease in U.S. emissions.

Aaron J. Cohen, of the Health Effects Institute, examined the relationship between air quality and public health. He outlined how different components appear to have different effects:

- Carbon monoxide – circulatory system, heart
- Ozone – respiratory system, lung
- Lead – nervous system, brain
- PM – lung, potential effects on heart
- Diesel, air toxics – cancer, respiratory effects

Cohen talked about studies done in 1993 (the Harvard Six-Cities Study) and 2002 (an American Cancer Society study) that found an association between longer-term average PM (fine particles) exposure and mortality.

Cohen talked about some of the methods used to measure the health impacts of improvements in air quality – some were more indirect, including models using existing risk coefficients; others were more direct, using estimates from studies of the actual policy interventions (banning sale of coal in Dublin, reducing sulfur in fuel in Hong Kong, etc.)

Session II-C: Energy security implications

Session introduction

Walter Short, NREL, chair

Energy and Political Stability

Gary Jones, Sandia National Laboratories (SNL)

Energy and Water

Allan Hoffman

U.S. Department of Energy and Winrock International (secondment)

The following questions were addressed:

What are the key links between security (energy and other) in the United States and global energy-systems development?

- Systemic poverty and the lack of a “middle class” contributes to political instability and is a breeding ground for terrorism.
- Middle-class creation requires broad, proactive, culturally acceptable programs – energy is a key enabling technology.
- Water security is the ability to access sufficient quantities of clean water to maintain minimal standards of food and goods production, sanitation, and health
- Water and energy issues are inextricably linked – central to addressing water security issues is having the energy to extract, transport, manage, treat, desalinate water resources.
- Energy is an enabler – it makes development needs accessible and strengthens economic progress.
- Energy also helps with social development – for instance, it can help provide efficient, low-cost telecommunications technologies.

How much do U.S. security impacts depend on what energy resources and technologies are used in global energy-systems development?

- Development of a technology-based manufacturing sector leads to a viable middle class.
- Water – there are no substitutes. The struggle to control water resources has shaped our political and economic history. Energy is key to producing a clean water supply.
- Water is not distributed uniformly around the globe and has been a source of tension wherever water resources are shared by neighboring groups.
- Shortages of water can lead to conflict in many parts of the world where water is a transboundary issue, creating national security problems for the United States.
- Water allocation can be a vehicle to engage regional parties in constructive dialogue.
- Sustainable global economic development is a major U.S. foreign policy goal. Water and energy are the critical elements of sustainable development.

- U.S. experience with water resources and their effective management leads the world.
- The worldwide market in water technologies is estimated at \$300 billion during the next decade.

What are the security pros and cons related to the role of renewables in global energy-systems development?

- Pro: By breaking the poverty cycle, you enhance the quality of life of the developing world. It's key to providing the means (such as energy) for rural and urban communities in the developing world to meet the basic needs of the current generation, but to maintain their own socio-political framework and resource base – and it must respect cultural traditions and be internally sustainable through community wealth creation.
- On the con side: If development efforts are not funded relative to size and needs of targeted regions, they may backfire.
- Con: To address unrest, development must provide economic alternatives to potential terrorist recruits and create a middle class with a vested interest in peace.

What key questions regarding this issue deserve further study?

- We need to determine which programs enable people to move forward on their own and empower them to find solutions as equals on a multinational level.
- Considerable effort must be expended to identify and characterize water resources, as well as design supply systems appropriate to local circumstances.
- We need to identify appropriate energy options needed to meet water security needs
- A major analytical effort is needed to identify the steps necessary to meet development goals.

Gary Jones' presentation provides an overview of the roots of terrorism and the potential role of decentralized modern energy services in supporting social and economic development. The link between fostering social and economic development and inhibiting terrorism is being examined³ intensively, and is increasingly understood. NREL benefits from understanding the kinds of rural social and economic development initiatives that can make a near-term and significant difference for poor families and communities. Local initiatives that focus on communities having reliable drinking water, upgraded schools and health clinics, and rural enterprises that employ local people with a living wage, typically take place where there is no electric grid and only informal electricity supply (by small privately owned diesel gen-sets). Decentralized / dispersed renewable energy systems (as well as hybrids and small fossil fuel units) can provide the electricity, shaft horsepower, and heat needed by rural enterprises to be productive and profitable.

By understanding the links from renewables to community services and to economically productive activities, NREL and its partners can better identify the technology options available to address local development needs. However, this is not a priority area for NREL, per se. Through partnership with organizations focusing on these issues, NREL can have access to the latest expertise and understanding, and can also have a widening network of contacts that can use NREL's expertise for enhancing rural development in troubled areas. This is also a context for NREL's ongoing international activities that are contributing to the use of renewable energy systems to support local economic and social development.

Overall, the panel members agreed that energy is an enabler – it makes development needs accessible and strengthens economic progress. They also recognized that shortages of resources (such as energy and water) can lead to conflict in many parts of the world, resulting in national security problems for the United States.

³ Kim Cragin and Peter Chalk (2003). Terrorism and Development: Using Social and Economic Development to Inhibit a Resurgence of Terrorism. RAND.

Session II-D: International development implications

Session introduction

Debra Lew, NREL, chair

Development Challenges

Griff Thompson, USAID

Energy and Agriculture

Gustavo Best, UN Food and Agriculture Organization (FAO)

Productive Uses of Clean Energy

Daniel Kammen, University of California, Berkeley

The panelists were asked to focus on the following questions:

How well do we understand the role of energy-systems development in international economic development?

- The U.S. scorecard is “mixed” when it comes to international economic development.
- The trend toward decentralization in political, administrative, and fiscal affairs – and the technological ability to produce energy at services at these local levels – is a key to future development.
- When power and resources are contained in smaller administrative units, it leads to better decision-making – there is a symbiotic relationship between distributed generation and democracy/governance.
- Food production function – energy is needed to produce food, and the food also can become energy.
- Agriculture is the biggest water consumer – it uses about 70 percent of all freshwater withdrawals worldwide.
- “Electric grid-connected envy” has crowded out important commercial system options, such as small-scale wind energy and solar-thermal systems.
- The agricultural sector is not well understood or explored regarding energy flows and opportunities.

What are the pros and cons of expanding the use of renewables to support economic development?

- Con: Too little attention has been paid to the impact of technological choices – we need to view energy technologies as extended systems.
- The obvious “pro” is immediate benefits of economic growth, health and education.
- The discovery of new energy sources and technologies translates into new patterns of discipline, authority, and economic and political organization.
- Renewable energy can be used for productive uses – this is a priority. The synergies of biomass, for example: A farmer can become an energy producer and “agroindustry” can contribute to the energy balance.
- Bioenergy supports agricultural diversification, and agriculture contributes to the world environment – food security is enhanced.

What are the implications for the United States?

- An impoverished world presents security threats to the United States – there is both a moral and economic imperative for the United States to do a better job in this field.

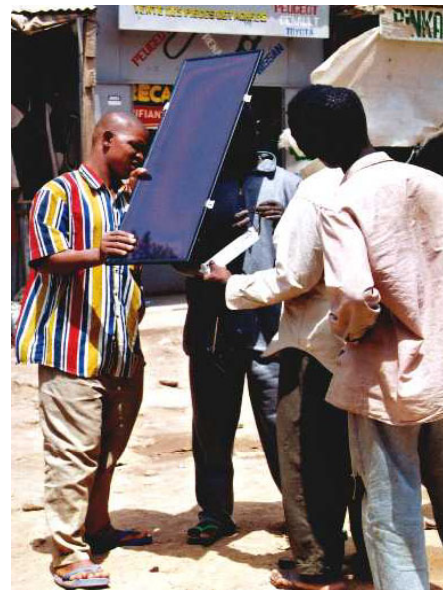
- The world is better off – producers and consumers – with growing GNPs throughout the developing world.
- The United States has considerable knowledge in renewable technologies that are used in agriculture – solar systems, wind energy systems, high-tech bioenergy production, etc. – that can be shared.
- The United States can contribute to rural development, reduce urbanization, and enhance confidence in the rural poor.
- We need to move beyond simple energy consumerism – for instance, biomass at small and large scales has great economic potential.
- There has been excessive attention on the romance of the market (supply and demand), which mostly means finding ways to sell things to poorer people.

Overall, the panel emphasized that there is enough knowledge on science and technologies, but not enough on implementation and locally economic applications. There is a lot of understanding on social/cultural issues, but this often is forgotten. Increased international development needs to start on a smaller scale – by focusing on local-level approaches, where decision-making is accelerated and people take increased “ownership” for development of their communities.

Griff Thompson, of the U.S. Agency for International Development (USAID), emphasized that efforts to shift power and resources to smaller administrative units would result in better decision-making, due partly to greater inclusivity and an increase in social welfare. He emphasized that tethering distributed energy systems to this trend will result in greater levels of success both for the goals of political decentralization and for the goals of expanded provision of energy services.

He sees a symbiotic relationship between, what he called, Distributed Generation and Democracy and Governance (DG2). By “unshackling” local authorities from distant and unresponsive utilities (which provided poor quality of power or no power at all), they possess the autonomy and ability needed to improve the social welfare of their communities.

Thompson’s overall answer to local economic development in international countries starts with viewing energy technologies as extended systems. In pursuing the democratic path to economic, social, and political development, attention has to be paid to the impact of technological choices and the systems to which they lead.



Courtesy Dan Kammen

Dan Kammen, with the University of California at Berkeley, also discussed the importance of economic development on the local level. Income generation is not a traditional “niche” for renewables. However, there are opportunities to work with traditional development approaches and groups interested in economic development.

Kammen outlined some of the key renewable technologies and their potential for contributing to international development. He cited biomass as one of the most attractive opportunities, both in its results and the labor required for its application. While this focus could lead to equity implications through distributed access, Kammen also noted the pressure that could be added on already overworked rural women.

Currently, wind and micro-hydro power are the most productive in the international arena. Wind energy is key in producing water through more than 1 million pumps; and micro-hydro power is essential in power-

ing small industries and the tourism business. However, the current “favorite” renewable energy technology in the world is solar photovoltaics. While this technology has made inroads, the lack of expertise among the vendors in application has reduced the economic impact.

Kammen sees opportunities that have been neglected and he supports a renewables market that moves beyond simple energy consumerism. For instance, finding a fuel and stove combination that reduces morbidity is paramount – and it will make the largest impact on workforce availability. He also emphasized the economic potential of biomass (on a small and large scale), reiterating that he thinks one quarter of the world’s energy could come from biomass. He also cautioned about the “romance of the market,” which focuses on finding ways to sell things to poorer people. He emphasized the need for a major initiative to work with end-users on identifying and developing better applications of the technology.

Session II-E Implications for the United States and discussion of analytical framework

Synthesis of Day One and Framework for Group Deliberations

Ron Benioff, NREL

Work group tasks:

- Identify the most important analytic issues for each topic and prioritize
- For each priority issue, answer three questions –
 1. What do we currently know?
 2. What don’t we know?
 3. What analysis is needed?
- Consider two crosscutting issues:
 1. What do we need to know to better understand the current and future energy context and its implications for the role of renewable energy in our four strategic areas?
 2. What do we need to know to better define a new renewable energy paradigm?

Session III: Improving our understanding: What additional data, information, and analysis are needed?

In order to enable participants to more actively and intensively engage in forum deliberations, participants were divided into four smaller groups to discuss the “key questions” presented during the forum. Working Group reports were prepared in the following areas (and are included in the Annex containing all of the presentations): market implications, environmental implications, energy security implications, and international development implications.

Each of the groups – Market, Environment, Energy Security, and International Development – was asked:

- What’s the development strategy?
- How do we better communicate our understanding?
- Does what we’ve discussed have any program or policy implications?

Organizers asked the groups to focus on their sectors and develop a statement on the analytic status and the most critical information/analytic needs. In addition, they were asked to make prioritized recommendations for meeting those needs.

Markets group

What is known:

- Global demand for renewable energy is increasing (9.25% per year), with wind technology as the bulk of the growth and significant growth in small hydro, biomass, photovoltaics, and geothermal
- Key market drivers include cost reductions, government policy, energy security, uncertainty of fossil fuel price and supply, environment, climate change, and air quality
- Increasing number of corporate players
- Not just about power – also heating, cooking, transport
- Major applications are productive, social, and consumptive
- Issues are also institutional, policy, awareness, and capacity

Analytic needs:

- Quantification of benefits, applications, and costs
- Site-specific resource assessments, market studies, options analysis, modeling
- Policy/regulatory impact assessments
- Information on viable business models/approaches
- Outreach to policy makers, regulators, consumers, financiers
- Information on compatibility with other technologies
- Generation/infrastructure limitations

Strategic considerations:

- Prioritize data/analysis needs with limited funding
- Inventory organizations doing work in similar areas
- Determine real gaps/needs
- Identify interested organizations/audience
- Link to ongoing partnerships (GVEP, EU)
- Engage business in the process
- Leverage funding from other sources
- Partner with innovators, leaders, organizations (energy and nonenergy)

Recommendations:

- Determine policies that will be most effective in positioning renewable energy to meet global demand
- Influence U.S. export promotion policies and client-country policies
- Study global markets to determine the competition and what the competitive advantage is for the United States
- Conduct analysis that is country- and market-specific (need to quantify benefits and costs, determine effectiveness of subsidies, etc.)
- Develop a Web-based clearinghouse for developers/financiers
- Link to nonenergy industries who need power in rural areas where it doesn't exist
- Develop tools for market assessment, resource assessment, technology comparison, willingness-to-pay inference, etc.

Environment group**What is known:**

- Climate change issues – massive change is needed to stabilize GHG emissions, and one probable GHG stabilization scenario relies on huge renewables deployment
- Air-quality issues – fossil-fuel technologies cause substantial long-range transport of pollutants to the United States, and significant international deployment of renewable energy will reduce this burden and costs of attainment of U.S. air-quality goals
- Health issues – there are high health costs from air pollution caused by fossil fuels and other sources, resulting in at least 800,000 premature deaths a year
- Renewable energy can achieve simultaneous multipollutant reductions
- Renewables can improve access to clean water

Analytic needs:

- Methods to explain environmental issues regarding climate change, air quality, and others (water, solid waste)
- Comparisons of environmental effects under different scenarios – quantify environmental impacts (including local) and use the results to influence of environmental effects on market decisions (emissions trading)

Strategic considerations:

- Decision makers need to understand what's needed for business infrastructure to make international deployment effective
- Information needs to be “strong” regarding U.S. business interests in renewable technology exports
- Information needs to support education and outreach

Recommendations:

- We have relatively well-known data and methods to quantify emissions changes due to renewable electricity generation – however, the attribution of specific health effects to specific sources of emissions is not well-quantified and is necessary
- We need to have the effects of air quality on human health quantified overseas, as well as it is domestically – European efforts used fixed energy scenarios
- Influence policy makers by focusing on their priorities
- Provide information on areas where renewables can significantly reduce GHG emissions, as well as information on what it will take to achieve large-scale deployment of renewables to stabilize these emissions.

- Provide clear analysis of options to stabilize GHG – this is key
- Obtain information on what air pollution emissions reductions can be achieved from renewables and what sources they'll displace
- Provide data on the health impacts of alternative renewable energy technologies relative to other options

Energy security group

What is known:

- Renewable energy may be able to reduce global reliance on – and conflicts over – access to petroleum and natural gas
- Systemic poverty and lack of middle class are contributing causes for terrorism
- Limited access to clean water is highly destabilizing and affects U.S. security

Analytic needs:

- Determine countries/regions and sectors where renewables can make significant contributions to energy self-reliance
- Define key roles renewables can play in economic development, stability, and globalization
- Quantify the connections between energy access and terrorism and the contribution renewables can make to mitigating these causes
- Quantify the contributions renewable energy can make to clean-water access
- Determine key roles renewables can play in disaster relief
- Analyze whether we can quantify the role of renewable energy in creating a stabilized “middle class”
- Determine whether we can quantify the impact renewables can have on world oil and gas prices through reduced demand

Strategic considerations:

- Determine whether renewable energy can significantly support supply-side fuels in the long term (50 years)
- In regard to electricity, we need to know whether renewables increase the security of the U.S. grids?
- Determine whether population stabilization and economic development can mitigate terrorism
- Determine the role of sustainable economic development in supporting a developing world

Recommendations:

- In a framework for fuels, measure the potential by source and cost, provide information on the geography of the supply, and show the demand forecast
- When considering electricity, we need to supply information on power flows and stress points, and provide grid modeling
- Pinpoint the role of distributed generation
- Devise a framework that links economic development, disparity, and terrorism
- Develop a community-level validated model

International development group

What is known:

- Access to even small amounts of modern energy can have a big development impact

- Rural energy services can improve socioeconomic development, which can decrease the impetus for urban migration – renewables can be the best choice for these services
- Economic development is crucial – renewable energy can be used for productive uses for income generation in remote, rural areas
- There is a strong renewable/agricultural symbiosis – renewables can be used for food production, which in the end can become energy
- Political impacts – decentralization of energy systems in occurring in tandem with the decentralization of political power
- Social impacts – renewables can improve public health, education, and overall quality of life

Analytic needs:

- Determine economic development benefits associated with renewables in rural areas
- Analyze the relationship between decentralization of political power and energy systems
- Quantify the benefits of renewables to social development, including health, education, water, etc.
- Determine the steps required to allow renewables to make a larger contribution to development – and how we can integrate international renewables with these programs
- Analyze whether we can quantify the benefits to the U.S. through development
- Determine how we can enhance public awareness of the key roles of renewable energy

Strategic considerations:

- Define the role that renewables can play in IT, telecommunications, and other new industries
- Provide development assistance for simple technologies that will refine and expand distribution
- Demonstrate that a solid water supply can contribute to economic growth
- Demonstrate the important link between agriculture/food production and bioenergy
- Reinforce the fact that market potential and commercial opportunities are key drivers in economic development

Recommendations:

- Develop analysis to determine how best to aggregate projects that show significant carbon offsets and minimize transaction costs – and share the information with the private sector
- Seek information that shows demographic trends, energy trends, and the role of renewables
- Demonstrate how renewable energy translates into economic benefits
- Provide information on the real potential of drip-irrigation systems with photovoltaics
- Provide analysis that shows the availability of land for bioenergy and food
- Develop a methodology for monitoring and evaluating the effectiveness of renewable energy/development initiatives

Energy Analysis Forum Summary Report Appendices

Appendix 1 - Forum Agenda

7:30 – 8:00 **Registration and continental breakfast**

Session I - Introduction

8:00 – 8:15 **Welcome to the forum**

Richard Truly, NREL

8:15 – 8:30 **Forum purpose**

Eldon Boes, NREL

8:30 – 8:50 **USAID perspective**

Griff Thompson, USAID

8:50 – 9:10 **DOE perspective**

John Millhone, DOE

9:10 – 9:50 **Setting the context**

Roger Taylor, NREL

9:50 – 10:05 Break

Session II – Global costs and benefits of increased use of renewables

Session II.A – Market implications

10:05 – 10:15 **Session introduction**

*Judy Siegel, Energy and
Security Group, chair*

10:15 – 10:30 **“Global Markets for Renewable Energy”**

Lisa Frantzis, Navigant

10:30 – 10:45 **“Energy: A European Perspective”**

Rick Sellers, IEA

10:45 – 11:00 **“Energy Industry Perspectives”**

Pete Duprey, GE Power Systems

11:00 – 11:15 **“Renewable Energy Markets in Developing
Countries”**

Eric Martinot, GEF

11:15 – 11:35 **Discussion period**

Panel and Audience

11:35 – 12:30 Working lunch

Session II.B – Environmental implications

12:30 – 12:40 **Session introduction**

Skip Laitner, EPA, chair

12:40 – 12:55 **“Long-Range Air-Transport Issues”**

Terry Keating, EPA

12:55 – 1:10 **“Climate-Change Issues”**

Jae Edmonds, JGCRI

1:10 – 1:25 **“Air Quality and Public Health”**

Aaron Cohen, HEI

1:25 – 1:45 **Discussion period**

Panel and Audience

Session II.C – Energy security implications

1:45 – 1:55 **Session introduction**

Walter Short, NREL, chair

1:55 – 2:10 **“Energy and Political Stability”**

Gary Jones, Sandia Labs

2:10 – 2:25 **“Energy and Water”**

Allan Hoffman, USDOE

2:25 – 2:45 **Discussion period**

Panel and Audience

2:45 – 3:00 Break

Session II.D – International development implications

3:00 – 3:10	Session introduction	<i>Debra Lew, NREL, chair</i>
3:10 – 3:25	“Development Challenges”	<i>Griff Thompson, USAID</i>
3:25 – 3:40	“Energy and Agriculture”	<i>Gustavo Best, FAO</i>
3:40 – 3:55	“Productive Uses of Energy”	<i>Dan Kammen, UC Berkeley</i>
3:55 – 4:15	Discussion period	<i>Panel and Audience</i>
<i>4:15 – 5:00</i>	<i>Discussion period</i>	<i>Session Chairs/Audience</i>

***** **End of Day One** *****

Session II.E – Summary of implications for the United States and discussion of analytical framework.

8:00 – 8:30	Synthesis of Day One and Framework for Group Deliberations	<i>Ron Benioff, NREL</i>
8:30 – 9:15	Panel and Group Discussion	<i>Session Chairs/Audience</i>

Session III – Improving Our Understanding - what additional data, information, and analysis is needed?

- What's the strategy for developing it?
 - How do we better communicate the understanding we have?
 - Does what we've discussed have any program or policy implications?
- (These topics to be addressed by topical Working Groups)

9:15 – 11:30	Working groups meet
	A. Market – Judy Siegel
	B. Environmental – Skip Laitner
	C. Energy security – Walter Short
	D. International development – Debra Lew

11:30 – 12:30 Working lunch

12:30 – 2:00 Working Group reports

2:00 – 3:00	Facilitated discussion	<i>Eldon Boes and Roger Taylor, NREL</i>
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***** Forum closing at 3:00 p.m. *****

Appendix 2 - Forum Presentations and Documents

Some of the following documents are available as Adobe Acrobat PDFs. [Download Acrobat Reader](#)

The underlined presentation titles and presenter names are linked to the presentations and biographical summaries on the NREL Web site.

Session I: Introduction

- Welcome - ([MS Word 29 KB](#)) [Richard Truly](#), NREL
- Forum purpose - ([PowerPoint 246 KB](#)) - [Eldon Boes](#), NREL
- USAID perspective - ([MS Word 53 KB](#)) [Griff Thompson](#), USAID
- DOE perspective - ([PowerPoint 2.86 MB](#)) - [John Millhone](#), DOE
- Setting the context - ([PowerPoint 20.0 MB](#)) - [Roger Taylor](#), NREL

Session II: Global costs and benefits of increased use of renewables

Session II.A Market implications

- Session introduction - ([PowerPoint 116 KB](#)) - [Judy Siegel](#), Energy and Security Group, chair
- Global Power Markets: Why Should the U.S. Care? - ([PDF 489 KB](#)) - [Lisa Frantzis](#), Navigant
- Renewable Energy: A European Perspective - ([PowerPoint 1.71 MB](#)) - [Rick Sellers](#), IEA
- Energy Perspectives: A Promising Future - ([PowerPoint 19.8 MB](#)) - [Pete Duprey](#), GE Power Systems
- Renewable Energy Markets in Developing Countries - ([PDF 353 KB](#)) - [Eric Martinot](#), GEF

Session II.B Environmental implications

- Session introduction - ([PowerPoint 425 KB](#)) - [Skip Laitner](#), EPA, chair
- Long-Range Transport of Air Pollution - ([PowerPoint 4.02 MB](#)) - [Terry Keating](#), EPA
- Climate-Change Issues - ([PowerPoint 1.65 MB](#)) - [Jae Edmonds](#), JGCRI
- Air Quality and Public Health - ([PowerPoint 1.04 MB](#)) - [Aaron Cohen](#), HEI

Session II.C Energy security implications

- Session introduction - ([PowerPoint 116 KB](#)) - [Walter Short](#), NREL, chair
- Energy and Political Stability - ([PowerPoint 1.50 MB](#)) - [Gary Jones](#), Sandia Labs
- Energy and Water - ([PowerPoint 84 KB](#)) - [Allan Hoffman](#), Winrock International

Session II.D International development implications

- Session introduction - ([PowerPoint 117 KB](#)) - [Debra Lew](#), NREL, chair
- Development Challenges - ([MS Word 40 KB](#)) [Griff Thompson](#), USAID
- Energy and Agriculture - ([PowerPoint 2.75 MB](#)) - [Gustavo Best](#), FAO
- Productive Uses of Clean Energy - ([PowerPoint 4.79 MB](#)) - [Dan Kammen](#), UC Berkeley

Session II.E Summary of implications for the United States and discussion of analytical framework

- Synthesis of Day One and Framework for Group Deliberations- ([PowerPoint 97 KB](#)) - [Ron Benioff](#), NREL

Session III: Improving our understanding: What additional data, information, and analysis are needed?

Working Group reports

- Market implications ([PowerPoint 25 KB](#))
- Environmental implications ([PowerPoint 865 KB](#))
- Energy security implications ([PowerPoint 70 KB](#))
- International development implications ([PowerPoint 25 KB](#))

Appendix 3 - Forum Speakers and Panelists

Ron Benioff, National Renewable Energy Laboratory: Ron Benioff serves as manager of Weatherization and Intergovernmental Programs for the National Renewable Energy Laboratory (NREL). In this capacity, he directs the Lab's work to promote implementation of renewable energy and energy efficiency technologies in collaboration with federal, state, and local agencies, as well as international partners. This includes delivery of NREL technical support for DOE's Clean Cities, International, Rebuild America, State Energy, and Tribal Energy programs and related activities in partnership with EPA, USAID, UNEP, UNDP, and the World Bank. Prior to joining NREL in 1997, Ron worked at the U.S. Environmental Protection Agency for 11 years on climate-change and waste-management issues. Ron has a master's in public administration from Indiana University and a bachelor's in biology from the University of Illinois.

Gustavo Best, Food and Agriculture Organization of the United Nations: Gustavo Best is the senior energy coordinator of the Food and Agriculture Organization (FAO) and is based in its Rome headquarters. From Mexico, Gustavo works primarily on the development and management of energy policies related to agriculture and rural development, with a strong emphasis on the application of bioenergy and other renewable energy sources to productive uses. He also stresses the energy-producing role of agriculture and forestry as an important path toward diversification, climate-change mitigation through biofuels, and consolidation of rural infrastructure. Essential elements in his work are the links between the energy and the agriculture sectors. Rural energy policies are mainly lacking in developing countries, and Gustavo has provided assistance to a number of countries to bridge this important gap. His work on renewable energy started in 1973 in the field of solar energy at the University of Mexico (UNAM), and continued with the Economic Commission for Latin America and the Caribbean, working from Santiago (Chile) and New York. He has been part of the FAO since 1986. Gustavo has a degree in chemical engineering from the UNAM and a Ph.D. from the University of Bradford in the U.K. He has taught thermodynamics and supervised students at postgraduate level. He lives in Rome but maintains close ties with his research team in Mexico.

Eldon Boes, National Renewable Energy Laboratory: Eldon Boes is the director of NREL's Energy Analysis Office, which includes analysts working both at NREL's primary location in Golden, Colorado, and in NREL's Washington office. He also is manager of NREL's Washington office. Eldon works primarily on the development and management of a strong Energy Analysis Program at NREL in support of the planning, management, and representation of renewable energy and energy efficiency programs at the Lab and at DOE. He began his career in renewable energy working on solar resource assessment at Sandia National Laboratories in 1974. During the next 16 years at Sandia, Eldon worked in several solar technology program areas including photovoltaics (PV) systems and applications development, PV concentrator R&D, and solar thermal collector development. He also served as supervisor or manager of several solar programs including the PV Program at Sandia. Eldon has a Ph.D. in mathematics from Purdue University, and he taught mathematics for eight years before joining Sandia. He and his wife, Joan, live in Alexandria, Virginia. Eldon has been commuting by bicycle for 39 years.

Aaron Cohen, Health Effects Institute: Aaron J. Cohen is principal scientist at the Health Effects Institute (HEI) in Cambridge, Massachusetts, where he has been employed since 1990. At HEI, he manages a program of epidemiologic research on the health effects of air pollution, and is involved in scientific program development. Aaron received his D.Sc. in epidemiology (1991), and master's in public health (1985) from the Boston University School of Public Health. He also is a registered respiratory therapist (AS and BS, Northeastern University), and worked as a therapist in newborn intensive care. He also worked as a research associate in perinatal epidemiology at Brigham and Women's Hospital in Boston, where he conducted epidemiologic and clinical research on neonatal respiratory disease, and the evaluation of related medical technologies. Since 1994, Aaron has been an adjunct assistant professor of environmental health

at Boston University School of Public Health, where he lectures on environmental epidemiology. He currently serves on the editorial board of the journal *Epidemiology*.

Peter Duprey, GE Power Systems: Pete Duprey is leader of business development for GE Power Systems, focusing on renewable energy. He led GE's acquisition of Enron Wind, and works closely with the GE Wind Energy team on growth initiatives in wind and other renewable areas. Peter has been with GE for 10 years, most of which was spent in GE Capital in diverse roles such as business development, finance, and quality. Pete graduated from Clarkson University with a bachelor's in accounting and finance and received an MBA from the William E. Simon School of Business. After graduation, he worked for PricewaterhouseCoopers in Rochester, New York. He then worked for Eastman Kodak developing their captive leasing business and came to GE as a result of GE Capital's acquisition of Eastman Kodak Credit Corporation, where he was the CFO. He and his wife, Kelli, live in Atlanta, Georgia, where they enjoy playing golf and cycling.

Jae Edmonds, PNNL Joint Global Change Research Institute: Jae Edmonds is a senior staff scientist and technical leader of Economic Programs at the Pacific Northwest National Laboratory's (PNNL) Joint Global Change Research Institute (JGCRI), a collaboration with the University of Maryland on the College Park campus. Jae heads an international global change research program at PNNL with active collaborations in more than a dozen institutions and countries around the world. He is the principal investigator for the Global Energy Technology Strategy Program to Address Climate Change, an international public-private research collaboration. Jae is widely known for his contributions to the field of the integrated assessment of climate change and the examination of interactions among energy, technology, policy, and the environment. He has expounded extensively on the subject of global change including books, papers, and presentations. He has served as a lead author for all three major assessments of the Intergovernmental Panel on Climate Change and numerous interim assessment reports. Jae has frequently testified before Congress and briefed the executive branch of the United States government, including the vice president of the United States and the U.S. Cabinet. He also has prepared and conducted numerous briefings and lectures to a wide range of audiences and serves on several editorial boards, review panels, and advisory committees.

Lisa Frantzis, Navigant Consulting: Lisa Frantzis is a director at Navigant Consulting, Inc., of Burlington, Massachusetts, and is responsible for the Renewable and Distributed Energy businesses. Prior to joining Navigant Consulting in 2002, she led the renewable energy consulting practice at Arthur D. Little for 23 years, where she conducted extensive technical, market, and economic analyses of renewable energy systems. She has provided due-diligence reviews of many different photovoltaic technologies for companies interested in investing in photovoltaics and has evaluated building integrated photovoltaics for utility and private-sector clients. Lisa also has reviewed the market potential and cost-reduction opportunities for wind, concentrating solar power systems, and geothermal technologies. She has evaluated the development of renewable energy systems globally, working at high levels of government agencies to determine the effectiveness and lessons learned of government policies such as renewable portfolio standards and subsidies on impacting renewable energy implementation and growth. A leader of numerous visioning workshops for the U.S. Navy, Environmental Protection Agency (EPA), and Department of Energy (DOE) on energy and renewable energy, Frantzis has worked with equipment manufacturers, environmental organizations, regulators, utility companies, oil companies, and government agencies, to identify action steps needed to achieve a desired energy outcome.

Allan Hoffman, Winrock International and USDOE: At the time of EAF-III Allan R. Hoffman was on detail from the U.S. Department of Energy (DOE), to serve as senior adviser to Winrock International's Clean Energy Group. Winrock International is a nongovernmental organization focused on sustainable economic development in developing countries. He has since (2004) returned to the USDOE. Allan came to Washington, D.C., in 1974 as a Congressional Fellow of the American Physical Society

and served in several roles, including staff scientist for the U.S. Senate Committee on Commerce, Science and Transportation; director, Advanced Energy Systems Policy Division, U.S. Department of Energy; assistant director for Industrial Programs, Energy Productivity Center, Mellon Institute; consultant and senior analyst, Office of Technology Assessment, U.S. Congress; executive director of the Committee on Science, Engineering, and Public Policy, NAS/NRC; and executive director of the National Research Council's Office of Government and External Affairs. In 1990, he returned to DOE where he has served as associate and acting deputy assistant secretary for Utility Technologies in the Office of Energy Efficiency and Renewable Energy. He also has served as U.S. representative to and vice chairman of the International Energy Agency's Working Party on Renewable Energy and as U.S. representative to the World Bank's Energy and Environment Steering Committee. Allan holds a Ph.D. in physics from Brown University. He also is a fellow of the American Physical Society and the American Association for the Advancement of Science.

Gary Jones, Sandia National Laboratories: Gary J. Jones is manager of International Partnership Development in the Corporate Business Development and Partnerships Center at Sandia National Laboratories. In this role, he is responsible for facilitation, coordination, and policy definition for the Laboratories' international partnering activities. In addition, Gary focuses on strategic business development for Sandia Laboratories' energy, environment, and critical infrastructure programs. He also works with Sandia's Advanced Concepts Group in the development of approaches to conflict prevention in the developing world, leading projects with Mexico and Jordan. Prior to joining this center, Gary spent 17 years working in Sandia's renewable energy programs. During this time, he held several positions, including manager of the Laboratories' photovoltaics and renewable energy programs. In 1993, Gary left these positions to spend two years as the senior technical adviser to the Solar Energy Industries Association and the U.S. Export Council for Renewable Energy under a government-industry partnership agreement. He has represented these organizations, Sandia, and the U.S. Department of Energy (DOE) in energy project activities in more than 20 countries. Gary has a bachelor's in physics from the University of Dayton and a doctorate in physical metallurgy from Iowa State University.

Daniel Kammen, University of California, Berkeley: Daniel M. Kammen holds multiple appointments at the University of California, Berkeley. He is a professor in the Energy and Resources Group, professor in the Goldman School of Public Policy, and professor of Nuclear Engineering. Dan also is the founding director of the Renewable and Appropriate Energy Laboratory (RAEL) where he works with faculty colleagues, several postdoctoral fellows, and about 20 students on a wide range of science, engineering, economics, and policy projects related to energy systems and the environment. The focus of Dan's work is on clean, renewable energy systems, energy efficiency, the role of energy in national energy policy, international climate debates, and the use and impacts of energy sources and technologies on development, particularly in Africa and Latin America. Dan has published five books, more than 150 journal articles, and 30 research reports. Dan is active in state, federal, and international energy policy affairs, and has field projects in East Africa, Mexico, Thailand, and China. He is the recipient of the 21st Century Prize (Japan).

Terry Keating, Environmental Protection Agency: Terry Keating is an air-quality scientist with the U.S. Environmental Protection Agency's (EPA) Office of Air and Radiation, where he advises senior management on scientific issues related to air-quality management at the national and international level. Terry earned a bachelor's in environmental science from the University of California at Riverside and a M.S.P.H. and Ph.D. in environmental sciences and engineering from the University of North Carolina at Chapel Hill. Working in government, academia, and private-sector consulting, Terry has participated in all levels of air-quality management ranging from the level of the individual facility to the level of international treaties. For the past several years, Terry has helped lead efforts within the EPA to examine the impact of the intercontinental transport of air pollutants on U.S. air quality.

John A. "Skip" Laitner, Environmental Protection Agency: Skip Laitner is the senior economist for technology policy in the Environmental Protection Agency (EPA) Office of Atmospheric Programs, a position he's held since 1996. In that capacity, he was awarded EPA's 1998 Gold Medal for his work with a team of other EPA economists to evaluate the impact of different strategies that might assist in the implementation of greenhouse gas emissions-reduction policies. Author of more than 150 reports, journal articles, and book chapters, Skip has more than 30 years of involvement in the environmental and energy policy arenas. He's been invited to provide technical seminars in diverse places including Australia, Canada, China, France, Germany, Korea, and South Africa. Skip recently served as an adjunct faculty member at the Virginia Polytechnic Institute and State University, teaching a graduate course on the economics of technology in the Science and Technology Studies program. He has a master's degree in resource economics from Antioch University in Yellow Springs, Ohio.

Debra Lew, National Renewable Energy Laboratory: Debra J. Lew is the Environmental and International group manager at the National Renewable Energy Laboratory (NREL). She leads NREL's International Program, which facilitates deployment of renewable energy and energy efficiency technologies in developing countries. She has worked at NREL for five years, previously leading NREL's activities in China, including grid-connected wind power, rural electrification, and energy efficiency. She also has worked at the International Institute for Energy Conservation in Bangkok, Thailand, and at Princeton University's Center for Energy and Environmental Studies. She has a doctorate in applied physics from Stanford and undergraduate degrees from MIT.

Eric Martinot, Global Environment Facility: Eric Martinot manages the renewable energy program of the Global Environment Facility (GEF) in Washington, D.C. His work includes program evaluations and research on emerging experience and lessons with markets, financing, and policies. Eric, an author of 50 publications on renewable energy and energy efficiency in developing and transition countries, received his Ph.D. in energy and resources from the University of California at Berkeley in 1995. He has served as a consultant for the World Bank, as a senior scientist for the Stockholm Environment Institute - Boston, as a convening lead author for the Intergovernmental Panel on Climate Change, and as an adjunct professor at the University of Maryland.

John Millhone, Office of Energy Efficiency and Renewable Energy: John P. Millhone is the program manager designate of the Office of Weatherization and Intergovernment Programs (OWIP) in the Office of Energy Efficiency and Renewable Energy (EERE) of the U.S. Department of Energy (DOE). OWIP will be responsible for EERE's Weatherization Assistance Program, State Energy Program, Community Partnerships, major deployment activities, and international and Native American activities. Since 1996, he has held positions in the U.S. Climate Change program as director of the U.S. Initiative on Joint Implementation and director of the U.S. Country Studies Program. Drawing on the U.S. experiences, the programs showed developing and transition countries how energy efficiency and renewable energy technologies can reduce greenhouse gas emissions. Prior to that, he took a two-year sabbatical from DOE to the Battelle/Pacific Northwest National Laboratory, where he was a Senior Fellow in the Advanced International Studies Unit. He was deputy assistant secretary for Building Technologies, responsible for DOE's building research and regulatory programs, from 1979 to 1994. Before joining DOE, John was director of the Minnesota and Iowa state energy offices. Long active in international activities, he was chairman of the End Use Working Party of the International Energy Agency (IEA) from 1979 to 1985. He was chairman of the IEA's Conference on End-Use Technologies and their Commercialization in Berlin in 1981 and editor of the three-volume proceedings of the conference. He helped create the IEA's Center for the Analysis and Demonstration of Demonstrated Energy Technologies (CADDDET) and was the first vice chairman of the CADDDET Executive Committee. John's earlier career was in journalism with the *Associated Press*, *Detroit Free Press* and *Des Moines Register and Tribune*. He has a bachelor of journalism degree from the University of Missouri and has done graduate work in law and political science.

Richard Sellers, International Energy Agency: Rick Sellers is head of the Renewable Energy Unit of the International Energy Agency (IEA) in Paris, France. The International Energy Agency is an autonomous agency linked with the Organization for Economic Cooperation and Development (OECD). The IEA is the energy forum for 26 member countries. Rick's unit is responsible for developing a strategy for accelerating renewable energy markets worldwide, as well as overseeing the coordination of member-country R&D. Before joining IEA, Rick had positions in government, industry, and trade associations. As deputy director of the U.S. Solar Energy Industries Association, he was involved in creating market development strategies for the solar industry. Rick received a bachelor's in American Studies (combined degree in history, political science, and government) from Wesleyan University in Middletown, Connecticut.

Walter Short, National Renewable Energy Laboratory: Walter Short is a principal policy analyst with the NREL Energy Analysis Office in Golden, Colorado. Walter works with the DOE Office of Energy Efficiency and Renewable Energy in formulating and analyzing policy initiatives with an emphasis on the market potential of renewable energy and climate change. As a part of his climate-change efforts, he was a coauthor on the inter-laboratory report, "Scenarios for a Clean Energy Future," examining the opportunities to address key energy and environmental challenges facing the United States through clean energy technologies and policies. Walter is now leading an effort to develop more detailed models for the market penetration of wind and solar. He also serves as group manager for the NREL analysis staff in Golden, Colorado. Walter has a bachelor's in mathematics from the University of Georgia and a master's in operations research from Stanford University.

Judy Siegel, Energy and Security Group: Judy Siegel is president of the Energy and Security Group. Judy has 25 years' experience in the commercialization of renewable energy technologies in more than 60 countries worldwide. She has extensive experience in developing and implementing renewable energy projects in Latin America, Asia, and Africa. Judy has served as president of the U.S. Export Council for Renewable Energy (representing more than 1,600 industry members), deputy director of the World Bank Asia Alternative Energy Program (ASTAE), and managing director of the Winrock International Clean Energy Group. Judy has worked with and continues to support a number of clients in the United States and overseas, including the U.S. Department of Energy (DOE), the National Renewable Energy Laboratory (NREL), the U.S. Agency for International Development (USAID), the World Bank, the United Nations, the Organization of American States, the U.N. Foundation, the Blue Moon Fund, and others. Judy has a bachelor's in economics and a master's in public administration.

Roger Taylor, National Renewable Energy Laboratory: Roger W. Taylor is manager of the International and Tribal Energy Programs at the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colorado. He works to expand and promote the use of renewable energy in support of sustainable economic development throughout the developing world - in collaboration with the U.S. Department of Energy, other U.S. government agencies, the renewable energy industry, foreign partners, financing, and development agencies. Roger has been extensively involved in application of renewable energy systems to the needs of developing countries since 1992. During the past 11 years, NREL has developed collaborations and substantive engagement with more than 15 countries. Roger's primary country foci have included Brazil, India, China, Egypt, Ghana, the Philippines, and Morocco. More recently, his experience is being focused on the development and implementation of renewable energy programs on Native American lands throughout the United States. Prior to working at NREL, he spent 15 years working on the integration of renewables with electric utilities, which included 10 years working with the Electric Power Research Institute and the EPRI-sponsored Power Electronics Applications Center.

Griffin Thompson, U.S. Agency for International Development: Griffin M. Thompson is energy team leader for the Office of Energy and Information Technology, U.S. Agency for International Development (USAID). As energy team leader, Griff directs energy and environmental technology programs in more

than 20 developing countries. The energy team's mission is to provide strategic, intellectual, and technical assistance in identifying activities that express the energy-development nexus. Prior to coming to USAID, Griff was the executive director of the International Institute for Energy Conservation (IIEC) and vice president of the Civil Engineering Research Foundation (CERF). Before his work at IIEC, he was the director of Asia Programs for the U.S. Export Council for Renewable Energy (US/ECRE), a business council representing the U.S. renewable energy industry. At US/ECRE, he coordinated the U.S. renewable energy industry efforts throughout the Asian Region. Griff was seconded to US/ECRE from the National Renewable Energy Laboratory (NREL) where he worked on a broad spectrum of international energy programs and strategic development. At NREL, Griff worked with the U.S. Department of Energy (DOE) on their international programs in Latin America, Africa, and Asia. His primary areas of emphasis are the soci-political dimensions of sustainable development and the institutional requirements of technology diffusion and adoption. Griff is a graduate of Gonzaga University and received his Ph.D. in political philosophy from Georgetown University in Washington, D.C. He lives in Derwood, Maryland, with his wife, Carmen Rojas, and their daughter, Camila.

Richard Truly, National Renewable Energy Laboratory: Richard Truly has been director of the Department of Energy's National Renewable Energy Laboratory (NREL) - which is operated by the Midwest Research Institute (MRI), Battelle, and Bechtel - since 1997. He is also the executive vice president of MRI. Prior to joining NREL, he was vice president of the Georgia Institute of Technology and director of the Georgia Tech Research Institute (GTRI) from 1992-1997. Richard served as NASA's eighth administrator under President Bush from 1989-92, and his career in aviation and space programs of the U.S. Navy and NASA spanned 35 years. He retired as a vice admiral after a Navy career of more than 30 years. His astronaut career included work in the Air Force's Manned Orbiting Laboratory program, and NASA's Apollo, Skylab, Apollo-Soyuz, and Space Shuttle programs. Still on active duty in 1986, Richard was called back to NASA as associate administrator for space flight in 1986, and led the accident investigation of the *Challenger* accident. He spearheaded the rebuilding of the Space Shuttle, including winning approval of President Reagan and the Congress for building of *Endeavor* to replace the lost *Challenger*. President Reagan awarded the Presidential Citizen's Medal to Admiral Truly in 1989. Richard is a member of the National Academy of Engineering, and is the recipient of honorary Doctorates of Science from Millsaps College and Duquesne University, and an honorary Doctorate of Engineering from Stevens Institute of Technology. Active in national and community affairs, he has served on the Board of Visitors to the U.S. Naval Academy, the Defense Policy Board, and the Army Science Board. He is a member of the Colorado Governor's Commission on Science and Technology, and on the Advisory Board of the Wirth Chair in Environmental and Community Development Policy, University of Colorado at Denver. Richard is a native of Fayette, Mississippi. He is married to the former Colleen (Cody) Hanner of Milledgeville, Georgia, and they have three children and five grandchildren.